

Radioactive Waste

Regulations

Regulations

1. Nuclear Regulatory Commission (NRC)

10 CFR 20 Subpart K. Various approved options for radioactive waste disposal. (See also Appendix F)

10 CFR 35.92. Decay in storage of medically used byproduct material.

10 CFR 60. Disposal of high-level wastes in geologic repositories.

10 CFR 61. Shallow land disposal of low level waste.

10 CFR 62. Criteria and procedures for emergency access to non-Federal and regional low-level waste disposal facilities.

10 CFR 63. Disposal of high-level rad waste at Yucca Mountain, NV

10 CFR 71 Subpart H. Quality assurance for waste packaging and transportation.

10 CFR 72. High level waste storage at an MRS

Regulations

2. Department of Energy (DOE)

DOE Order 435.1 *Radioactive Waste Management*. General Requirements regarding radioactive waste.

10 CFR 960. *General Guidelines for the Recommendation of Sites for the Nuclear Waste Repositories*. Site selection guidelines for a waste repository.

The following are not regulations but they provide guidance regarding the implementation of DOE Order 435.1:

DOE Manual 435.1-1. *Radioactive Waste Management Manual*. Describes the requirements and establishes specific responsibilities for implementing DOE O 435.1.

DOE Guide 435.1-1. Suggestions and acceptable ways of implementing DOE M 435.1-1

Regulations

3. Environmental Protection Agency

40 CFR 191. *Environmental Standards for the Disposal of Spent Nuclear Fuel, High-level and Transuranic Radioactive Wastes*. Protection for the public over the next 10,000 years from the disposal of high-level and transuranic wastes.

4. Department of Transportation

49 CFR Parts 171 to 177. These provide requirements pertinent to transportation of radioactive waste.

5. Local Municipalities

Local municipalities have no regulatory authority over radioactive material. Although they cannot restrict the disposal of waste because it is radioactive, they might make life difficult for the licensee.

NRC

10 CFR 20 Subpart K

NRC: 10 CFR 20 Subpart K

20.2001. General Requirements

(a) A licensee shall dispose of licensed material only—

- (1) By transfer to an authorized recipient as provided in § 20.2006 or in the regulations in parts 30, 40, 60, 61, 63, 70, and 72 of this chapter;
- (2) By decay in storage; or
- (3) By release in effluents within the limits in § 20.1301; or
- (4) As authorized under §§20.2002, 20.2003, 20.2004, or 20.2008.

Authorized Recipient

The licensee is responsible for ensuring that the company or individuals receiving the radioactive material for disposal are licensed to receive it. Copies of the license should be kept 7

NRC: 10 CFR 20 Subpart K

Decay in Storage

Decay in storage must be permitted in the facility license.

10 CFR 35.92 (for medical licensees) permits decay in storage of radionuclides with half-lives up to 120 days.

At the end of the decay period “its radioactivity cannot be distinguished from the background radiation level with an appropriate radiation detection survey meter set on its most sensitive scale and with no interposed shielding”

A pancake GM or other thin window detector might be used for beta emitters while a thin window low energy NaI detector or uR meter might be used for photon emitters).

NRC: 10 CFR 20 Subpart K

Decay in Storage

The count should be performed in a low background area.

In the case of a metal waste drum, the lid might be removed and a measurement made on top of the exposed bag. After carefully removing the bag from the drum, measurement s might be made on all sides.

Even though the low energy betas from H-3, C-14 or S-35 in the waste should not be detectable through a plastic bag, this type of measurement is still usually performed.

NRC: 10 CFR 20 Subpart K

Decay in Storage

Afterwards, radiation labels must be defaced or removed. At this point, the waste may be disposed of as ordinary trash.

Unless specified in the license or state regulation, there is no required decay period (e.g., ten half-lives).

Records pertaining to decay in storage must be maintained for at least three years. They include the date on which the waste was sealed for decay, the radionuclides involved, the type of survey instrument used, the name of the surveyor, the area background, the measurement on the surface of the waste container and the date of disposal.

NRC: 10 CFR 20 Subpart K

Decay in Storage

In some cases, long-lived impurities can complicate the decay in storage process by resulting in measurable levels of radiation after the decay process should be complete.

For example I-123 might contain trace amounts of I-124 and I-125. In-111 can contain small amounts of In-114m. Rb-86 can contain Cs-134 and Sm-153 might contain Cs-134.

NRC: 10 CFR 20 Subpart K

20.2003. Disposal by Release into Sanitary Sewerage

- (a) A licensee may discharge licensed material into sanitary sewerage if each of the following conditions is satisfied:
 - (1) The material is readily soluble (or is readily dispersible biological material) in water; and
 - (2) The quantity of licensed or other radioactive material that the licensee releases into the sewer in 1 month divided by the average monthly volume of water released into the sewer by the licensee does not exceed the concentration listed in table 3 of appendix B to part 20; and ..

NRC: 10 CFR 20 Subpart K

20.2003. Disposal by Release into Sanitary Sewerage

(3) If more than one radionuclide is released, the following conditions must also be satisfied:

(i) The licensee shall determine the fraction of the limit in table 3 of appendix B to part 20 represented by discharges into sanitary sewerage by dividing the actual monthly average concentration of each radionuclide released by the licensee into the sewer by the concentration of that radionuclide listed in table 3 of appendix B to part 20; and

(ii) The sum of the fractions for each radionuclide required by paragraph (a)(3)(i) of this section does not exceed unity; and

NRC: 10 CFR 20 Subpart K

20.2003. Disposal by Release into Sanitary Sewerage

(4) The total quantity of licensed and other radioactive material that the licensee releases into the sanitary sewerage system in a year does not exceed 5 curies (185 GBq) of hydrogen-3, 1 curie (37 GBq) of carbon-14, and 1 curie (37 GBq) of all other radioactive materials combined.

(b) Excreta from individuals undergoing medical diagnosis or therapy with radioactive material are not subject to the limitations contained in paragraph (a) of this section.

NRC: 10 CFR 20 Subpart K

Sanitary Sewerage Disposal - General

'Sanitary sewer' does not mean septic tank systems, leach fields, or treatment facilities owned or operated by the licensee. It applies to a system of public sewers.

A model procedure for disposal of liquid wastes into the sanitary sewerage can be found in Appendix V of NUREG 1556 Volume 11.

NRC: 10 CFR 20 Subpart K

Readily Soluble Criterion

Information regarding “readily soluble” is found in NRC NUREG-1736 and Information Notice 94-07.

Quoting NUREG-1736, “Readily soluble has not been defined in the regulations, but NRC requires that an evaluation be made by any appropriate means to determine the solubility, in water” “the evaluation may be theoretical, i.e., based on knowing the chemical characteristics of the compounds to be disposed, or on experimental determinations.”

NRC: 10 CFR 20 Subpart K

Readily Soluble Criterion

Theoretical approach described in IN 94-07: If the chemical form of the material is known, its solubility can be determined from the literature, e.g., CRC Handbook of Chemistry and Physics. Readily soluble materials include those characterized as very soluble (vs) or soluble (s).

Experimental approach described in IN 94-07 : Filtration of a representative sample using the methodology of ASTM Method D 1888-78 “*Standard Test Methods for Particulate and Dissolved Matter, Solids or Residue in Water*” or that of APHA Method 7110 “*Gross Alpha and Gross Beta Activity in the Standard Methods for the Examination of Water and Wastewater.*”

NRC: 10 CFR 20 Subpart K

Readily Soluble Criterion

The ASTM standard involves filtering the water through a 0.45 um membrane filter. Any residual activity on the filter above that of a filtered background sample indicates the presence of insoluble radioactive material.

The APHA method involves filtering the solution through a 2 um membrane filter.

NRC: 10 CFR 20 Subpart K

Readily Soluble Criterion

Solubility determination of Hotte and Sokolek (2001):

The liquid waste is mixed and three 10 ml aliquots are removed from the container. Two one ml samples are obtained from each 10 ml aliquot and analyzed by LSC. A total of six unfiltered 1 ml samples are analyzed.

4 mls from the remainder of each 10 ml aliquot is filtered through a 2 um membrane filter.

Two 1 ml samples from each of the three filtrates are analyzed by LSC.

NRC: 10 CFR 20 Subpart K

Readily Soluble Criterion

Solubility determination of Hotte and Sokolek (2001):

If a statistical analysis showed that there was no difference between the measurements made on the six filtered and six unfiltered solutions ($p < 0.05$), the radioactive component of the waste was assumed to be soluble.

NRC: 10 CFR 20 Subpart K

Readily Dispersible Criterion

NUREG-1736 states “Readily dispersible biological material was included in the regulation to permit disposal of certain research waste products, such as animal carcasses or tissues that have been finely ground.”

The BioSAFE Engineering/WR2 Tissue Digestor (formerly known as the Path-Clav system) solubilizes biological material including entire animal carcasses via an alkaline hydrolysis procedure. This product is directly connected to the drain system and leaves almost no residual material.

NRC: 10 CFR 20 Subpart K

Concentration of Radionuclides in Sewage Sludge

Radionuclides may concentrate in the sludge at the local sanitary sewage treatment facility.

This matter is addressed in NRC Information Notice 84-94.
Reconcentration of Radionuclides Involving Discharges Into Sanitary Sewage Systems Permitted Under 10 CFR 20.303.

Evaluating such a build up is normally the responsibility of the state radiation control program. In some areas workers are required to carry personnel dosimeters.

NRC: 10 CFR 20 Subpart K

Hot Sink

If individual users are permitted to dispose of liquid wastes in the sanitary sewer, a specific sink should be designated and identified for this purpose.

A log should be kept on all licensed material disposed of in the sink.

NRC: 10 CFR 20 Subpart K

Control of Disposal Into Sanitary Sewerage System

To prevent a facility from exceeding its monthly concentration or annual activity limits, restrictions might be placed on the amount that can be disposed of by individual users.

This might or might not require that the user seek permission from the radiation safety office prior to each disposal.

It is very common to prohibit individual users from disposing of material into the sanitary sewerage. Instead, liquid wastes are collected from the user by radiation safety and then disposed of at a central location under controlled and monitored conditions.

NRC: 10 CFR 20 Subpart K

§ 20.2004 Treatment or disposal by incineration

- (a) A licensee may treat or dispose of licensed material by incineration only:
 - (1) As authorized by paragraph (b) of this section; or
 - (2) If the material is in a form and concentration specified in § 20.2005; or
 - (3) As specifically approved by the Commission pursuant to § 20.2002.

NRC: 10 CFR 20 Subpart K

Disposal by Incineration

The only wastes that can be incinerated without the NRC's permission are certain oils (e.g., lubricants) used at nuclear power plants and LSC cocktails and animal carcasses contaminated with low concentrations of H-3 and C-14.

A good reference: ANSI N13.45-1998 *Incineration of Institutional Low-level Radioactive Waste*.

Quoting section 8.11 "Waste Management " in NUREG 1556 Vol.11: "Applicants proposing incineration should be aware that a notice in the Federal Register may be required before disposal of ash as ordinary waste can be approved."

NRC: 10 CFR 20 Subpart K

Disposal by Incineration

Incineration does not eliminate radioactive waste, but it can substantially reduce the volume of the waste. It might be done in an incinerator operated by the licensee, or the waste might be sent to a commercially operated incinerator.

The sorts of wastes processed by incineration include combustible solids, liquid scintillation cocktails (in plastic vials or other combustible containers), oils, and animal carcasses.

If the incinerator also handles non-radioactive wastes, it is best to run radioactive dedicated burns so that the ashes of the radioactive and non-radioactive wastes are not mixed.

NRC: 10 CFR 20 Subpart K

Disposal by Incineration

Waste might be incinerated in fiberboard drums since the latter are combustible and inexpensive.

Incineration of radioactive waste is less common today than it once was. In part, this is due to the difficulty in obtaining permission from the regulatory agencies. It is also due to the problems associated with handling radioactive ash.

NRC: 10 CFR 20 Subpart K

§ 20.2005 Disposal of Specific Wastes

- (a) A licensee may dispose of the following licensed material as if it were not radioactive:
 - (1) 0.05 microcurie (1.85 kBq), or less, of hydrogen-3 or carbon-14 per gram of medium used for liquid scintillation counting; and
 - (2) 0.05 microcurie (1.85 kBq), or less, of hydrogen-3 or carbon-14 per gram of animal tissue, averaged over the weight of the entire animal.
- (b) A licensee may not dispose of tissue under paragraph (a)(2) of this section in a manner that would permit its use either as food for humans or as animal feed.

NRC: 10 CFR 20 Subpart K

Disposal of Specific Wastes

While the material might be treated as if it were not radioactive, all relevant local, state and federal regulations pertaining to the chemical nature of the waste must still be adhered to.

Averaging the concentration over multiple animals is not permitted – the concentration is calculated for individual animals.

General Comments Regarding Waste Management

Waste Management

Training

Radioactive waste disposal is expensive.

Ensure that employees are trained in the techniques that can minimize the generation of such waste.

Among other things, users should be cautioned not to dispose of non-radioactive items (e.g., papers, plastic) as if they were radioactive. Such items can be surveyed prior to disposal.

Waste Management

Health Physics-User Relationship

For training to be effective, there must be a good working relationship between the waste generators (authorized users) and the health physics personnel.

Cooperation is more difficult to achieve in a research environment than a production facility.

Researchers often have little concern for the volume of waste they generate and the hazards posed by the radioactive materials they use.

Charging the researcher for waste disposal helps.

Waste Management

Health Physics- User Relationship

At a large institutions, waste is often taken by the user/researcher to a local collection area where it is picked up by health physics personnel. Alternatively, health physics personnel might pick up the waste at the site of generation. Waste collection might be performed at the request of the researcher (many facilities have on-line pick up request forms) or the pick ups might occur at regular intervals, i.e., at a specific time and day of the week.

Communication between the researcher and health physics is improved if a single HP is responsible for a given group of labs and if mechanisms are in place for frequent contact.

Waste Management

Maximize Disposal Options

Given a choice of several radionuclides, choose the one with a short half life, i.e., one that will permit decay in storage.

Segregate the use of short-lived and long-lived materials and separate waste at the source according to half life.

Separate waste at the source as known to be contaminated or possible contaminated.

Select protocols that do not combine radioactive materials and EPA designated hazardous wastes, i.e., avoid the generation of mixed waste. For example, rather than use organic solvents to degrease contaminated materials, use a citrus based degreaser.

Waste Management

Reduce the Quantity of Contaminated Material

Determine if the test/procedure might be performed without radioactive materials (e.g., stable or fluorescent tracers could be substituted for radiotracers). Unfortunately, the alternative methods might be less sensitive, less specific, and not as widely accepted. In addition, the researcher might have to devote additional time to learning the new methodology.

Don't purchase more activity than necessary just because a good deal is available on larger quantities.

Reduce the volume of non-radioactive material being used that will become contaminated waste. For example, reduce the volume of liquid scintillation cocktail in the vials.

Waste Management

Reduce the Quantity of Contaminated Material

Reduce the use of single-use materials, e.g., plastics, tape.

Control what is taken into and out of contaminated areas.

Segregate radioactive and non-radioactive materials and the equipment used to handle them. In some cases, color coding might be useful.

Consider decontaminating contaminated material rather than treating as waste (e.g. equipment).

Switch to materials that can be easily decontaminated.

Remove and dispose of the contaminated portion of the material or equipment rather than disposing of everything.

Waste Management

Return Source to Manufacturer

It is sometimes possible to return a source to the manufacturer. The ability to do so might have to be incorporated into the purchase agreement with the manufacturer, so plan ahead.

To facilitate a return, keep all the original packaging and paperwork that came with the source.

In the case of tritium containing exit signs, the manufacturer might accept an old sign at no charge if it is being exchanged for a new one. If it is not being replaced, the manufacturer would charge a fee for its return. Even if the manufacturer has gone out of business, a different company might be willing to accept the sign.

Waste Management

Waste Compaction

Compacting radioactive waste might not reduce the disposal cost. After all, the activity and mass of the waste are not affected.

Nevertheless, it can reduce the number of waste shipments and make better use of limited waste storage space.

Compaction might be done at a third-party commercial facility or in-house. The latter option can involve the use of a small kitchen compactor or a larger unit for compaction in 55 gallon drums.



S&G Enterprises 55Sc
Compactor

Waste Management

Waste Compaction

Plastic or other materials might expand following compaction. Expansion can be reduced by keeping the waste compressed (with the ram down) in the compactor for an extended period of time, e.g., 5 minutes. Another approach is to hold the compressed waste down with commercially available disks that are wedged tight against the inside walls of the drum. (e.g., S&G Enterprises Germantown WI).

Compactors can generate airborne radioactive material and must be considered a possible contamination source. This is particularly a concern for volatiles such as iodine. For this reason, decay in storage might precede compaction.

Waste Management

Waste Compaction

Another problem is that contaminated water or other liquids can be squeezed out of what otherwise would appear to be dry waste. This liquid waste that accumulates in the bottom of the waste container (e.g., drum) must then be disposed of.

Section 8.11 in NUREG 1556 Volume 11 (for broad scope licensees) states: “Waste compaction or other treatments can reduce the volume of radioactive waste, but such processes may pose additional radiological hazards (e.g., airborne radioactivity) to workers, members of the public, and the environment. Safety procedures to address these concerns should be implemented.” Appendix V of the NUREG provides information for a licensee proposing the use of in-house waste compaction.

Waste Management

Vial Crushers and Shredders

Liquid filled LSC vials can be processed via commercially available shredders or crushers that separate the solids from the liquids.

The glass fragments of the crushed vials, or the shredded fragments of plastic vials, can usually be washed and disposed of as non-radioactive waste. The liquids still have to be disposed of (e.g., disposal into the sanitary sewerage, incineration, etc.)

The shredding/crushing might be done in-house or off-site by a commercial vendor.

Waste Management

Vial Crushers and Shredders



Vyleater LSC vial crusher

Courtesy of S&G Enterprises.

Waste Management

Reduce Volume of Waste by Evacuating Waste Bags

By using a vacuum system to remove the air from plastic bags containing low level waste, the volume of the waste can be substantially reduced.

Evaporation of Liquid Wastes

Evaporation of liquid radioactive waste can be useful in circumstances where such waste cannot be disposed of into the sanitary sewerage.

Any solid radioactive residue that remains is easier to dispose of than liquid waste.

Waste Management

Send to Processor for Decontamination or Melting

Contaminated metal and equipment can be sent to a processor (e.g., Energy Solutions) for decontamination and/or melting.

Radioactive Source Recovery Program

This program operates out of Los Alamos National Laboratory. It was originally set up to accept sealed transuranic sources such as Am-Be and Pu-Be neutron sources. It has now been expanded to take other high activity sealed sources. Since the service can be free of charge, it can be a huge money saver. Mail address: osrp@lanl.gov. General phone number: 1-877-676-1749. <http://osrp.lanl.gov>

Waste Management

Recycle Radioactive Materials

Some companies (e.g., J.L. Shepherd) can recycle sources that have useful quantities of specific radionuclides. The charge for this service can be less than that of disposal. For further details contact the Conference of Radiation Control Program Directors (CRCPD) at (502) 227 4543.

Transfer Sources

Submit information about an unwanted source to the Conference of Radiation Control Program Directors who maintain a list of such sources. Many of the listed sources will find new homes and the only cost might be that associated with shipping the source to the new owner.

Waste Management

Extended Storage

Quoting Section 8.11 in NUREG 1556 Volume 11:

“The NRC does not consider storage as a substitute for final disposal of radioactive wastes. Other than storage for radioactive decay, LLW should be stored only when disposal capacity is unavailable, and for no longer than is necessary. NRC Information Notice No. 90-09, “Extended Interim Storage of Low-Level Radioactive Waste For Fuel Cycle and Material Licensees,” dated February 1990, provides guidance to licensees for requesting an amendment to authorize extended interim storage of LLW.”

More recent guidance is provided in regulatory Issue Summaries 2008-12 and 2008-32.

Waste Management

Medical Facilities

NRC guidance regarding waste handling programs at medical facilities can be found in Section 8.28 and Appendix W of NUREG 1556 Volume 9.

Waste containing the short-lived nuclides typically employed in nuclear medicine can be dealt with via decay in storage, while unwanted long lived brachytherapy sources and instrument quality control sources might be returned to the manufacturer.

Waste generated in a medical facility's research laboratories can be more problematic since the long-lived sources might not be sealed, and the waste forms are more varied, e.g., liquid scintillation cocktails, animal tissue, etc.

Waste Management

Medical Facilities

What should only be ordinary hospital trash can sometimes contain radioactive material (e.g., paper towels, pads, bed sheets, and clothing contaminated with excreta and other bodily fluids).

To prevent this waste from leaving the facility, hospitals might have survey instruments or monitors at trash collection points so that all trash is monitored before going into a dumpster.

When a radiation monitor at a municipal landfill alarms, state personnel can be called to the scene. If the trash is known to come from the medical facility, it can be rejected and the RSO called to deal with it. This often means that the RSO ends up sorting through the trash to identify the source.

Waste Management

Medical Facilities

Alarm thresholds at landfills can be very low, e.g., just above background, to ten times background. The NRC and the CRCPD recommend thresholds be set at 3 to 5 times background. If a low threshold is causing too many alarms and unnecessary trips to the disposal site, it might be possible for the medical facility to get the landfill to increase the thresholds on its detection equipment.

Some waste disposal sites are permitted by the state to accept certain types of waste contaminated with the short-lived radionuclides employed in nuclear medicine. Even so, the site should be given advance notice when such material is shipped for disposal.

Waste Segregation

Waste Segregation

General

Waste is often segregated at the point of generation (e.g., by the user) according to its:

- physical form
- chemical form or flammability
- half life

Physical Form Solids

Sharps (needles, razor blades)

Animal Carcasses

Liquids

Gases

Waste Segregation

Chemical Form or Flammability

Solids	Combustible (e.g., paper, plastics)
	Non-combustible (e.g., glass, metal)
Liquids	Aqueous (or miscible in water)
	Flammable Organic (e.g., toluene)
	Non-flammable Organic

Waste Segregation

Half-life

Short-lived radionuclides that are permitted to undergo decay-in-storage are separated from longer lived radionuclides that must be disposed of by some other means (e.g., disposal into sewer, burial, etc.).

The half-lives employed for segregation depend on what the license or regulations allow for decay in storage, e.g.,

- < 120 days (decay in storage)
- > 120 days (other disposal)

Waste Segregation

Half-life

Some facilities might segregate waste into three categories as follows:

Very short lived material might be allowed to undergo decay in storage at the point of generation (e.g., the lab), while longer lived materials are taken to a centralized waste storage/treatment facility for decay-in-storage, or other form of disposal:

- < 15 days (decay in storage in laboratory)

- 15 - 90 days (decay in storage at centralized facility)

- > 90 days (other disposal)

Waste Handling and Storage

Waste Handling and Storage

General

Protective clothing should be worn when handling radioactive waste (disposable gloves and a laboratory coat).

Short term storage of waste might take place near the point of generation (e.g., the lab). Long-term storage might occur at a more remote centralized location.

Waste storage areas must be secure. Emergency procedures and contacts should be posted near the entrance.

Waste should not be stored any longer than necessary since future options for waste disposal might be more limited and they will certainly be more expensive.

Waste Storage Areas

General

Waste should not be stored near counting equipment , occupied areas, or high traffic areas, e.g., hallways, stairwells or other uncontrolled areas. Liquid waste should not be stored in areas that would be difficult to clean in the event of a spill or leak.

Radioactive waste should not be stored in the same area as chemical waste.

Waste containers should be shielded, handled and arranged so as to keep the exposures to personnel ALARA, e.g., surrounding the high activity waste containers with low activity waste containers. At the same time, visual inspection of the containers should be possible.

Waste Characterization

Waste Characterization

General

Waste characterization means identifying and quantifying the radionuclides in order to determine the type and class of the waste.

The NRC provides limited guidance in 10 CFR 61.56a8.

Radionuclide concentrations in waste can be averaged over the entire volume or weight of the waste.

It is preferred, but not necessary, to directly measure the radionuclides in the waste.

Waste Characterization

General

The quantity of a radionuclide in the waste needs to be estimated, not determined with extreme accuracy.

The estimates of radionuclide concentrations in waste should not be overly conservative since the waste disposal site's license will limit the total activity of the waste permitted at the site.

Waste Characterization

Exposure Rate Measurements

The concentration of a single gamma emitter in the waste can be estimated by measuring the exposure rate (e.g., $\mu\text{R/hr}$) at a standard distance from the waste container.

Gamma Spectroscopy Measurements

Gamma spectroscopy (using NaI, LaBr or HPGe detectors) can be used to estimate the concentration of the various gamma emitters in the waste.

If the gamma spectroscopy system cannot be calibrated with suitable standards (i.e., sources similar in size, shape, and makeup to the waste) corrections to be made to account for geometry and self absorption effects.

Waste Characterization

Gross Beta Measurements

Gross beta measurements on the waste (e.g., performed on the outside of a clear plastic bag containing the waste) can be used to estimate the concentration of the various beta emitters if a ratio between the different beta emitters can be established.

Materials Balancing

Example: If you know how much activity goes into a process, the amount that ends up in the product, and the amount that decayed away, you can estimate the amount in the waste.

Waste Characterization

Scaling Factors

If radionuclide A is measured directly, and radionuclide B is known with 'reasonable assurance' to be present in a fixed ratio to radionuclide A, the concentration of radionuclide B can be estimated by multiplying the measured concentration of A by an appropriate scaling factor.

The issue of scaling factors is addressed in NRC Information Notice 86-20 *Low-level Radioactive Waste Scaling Factors*. The latter states that scaling factors are intended to be accurate within a factor of ten and that if confirmatory measurements indicate that the actual and predicted concentrations differ by more than a factor of ten, the licensee may be out of compliance with 10 CFR 61.55 (a) (8).

Waste Characterization

Scaling Factors

The information notice points out that scaling factors are specific to a given waste stream and that the use of a single scaling factor for all the facility wastes might be inappropriate.

Classification of Radioactive Waste in the U.S.

Types of Radioactive Waste

Types of Radioactive Waste

The classification of the waste can be based on some combination of the:

- origin of waste
- concentration of radionuclides
- half-life of radionuclides
- heat generation

Types of Radioactive Waste

Types of Radioactive Waste

In the U.S., the three basic types of radioactive waste are:

- High-Level Waste
- Low-level Waste
- Transuranic Waste

The NRC, DOE, and EPA definitions differ slightly and the distinction between the three waste types is not always clear.

There is also mixed waste: a combination of one of the above types of waste and hazardous waste.

By volume, the majority of radioactive waste generated in the U.S. is low-level waste. By activity, it is high-level waste.

Types of Radioactive Waste

High-Level Waste (HLW)

NRC Definition (10 CFR 60):

- “ (1) Irradiated reactor fuel,
- (2) liquid wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and
- (3) solids into which such liquid wastes have been converted.”

Types of Radioactive Waste

High-Level Waste (HLW)

DOE Definition (10 CFR 960):

- “(1)the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations and
- (2) other highly radioactive material that the NRC, consistent with existing law, determines by rule requires permanent isolation.”

[DOE defines spent nuclear fuel separately]

Types of Radioactive Waste

Transuranic (TRU) Waste

DOE Definition (M 435.1-1):

“Transuranic waste is radioactive waste containing more than 100 nanocuries (3700 becquerels) of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years, except for:

- (1) high-level radioactive waste;
- (2) waste that the Secretary of Energy has determined, with the concurrence of the Administrator of the Environmental Protection Agency, does not need the degree of isolation required by the 40 CFR Part 191 disposal regulations; or
- (3) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61.”

Types of Radioactive Waste

Low-Level Waste (LLW)

NRC Definition (10 CFR 62)

- “(1) Is not high-level radioactive waste, spent nuclear fuel, or byproduct material (as defined in paragraphs (2), (3), and (4) of the definition of *Byproduct Material* set forth in § 20.1003 of this chapter); and
- (2) The NRC, consistent with existing law and in accordance with paragraph (1) of this definition, classifies as low-level radioactive waste.”

Types of Radioactive Waste

Low-Level Waste (LLW)

DOE Definition (M 435.1-1):

“ Low-level radioactive waste is radioactive waste that is not high level radioactive waste, spent nuclear fuel, transuranic waste, byproduct material (as defined in section 11e.(2) of the *Atomic Energy Act of 1954, as amended*), or naturally occurring radioactive material.”

Types of Radioactive Waste

Low-Level Mixed Waste (LLMW)

Low-level mixed waste meets the NRC's definition of low-level waste and at the same time contains material identified as hazardous waste in 40 CFR 261 Subpart D, or causes the LLW to possess any of the hazardous waste characteristics identified in 40 CFR 261 Subpart C (e.g. ignitable, corrosive, toxic etc.).

Common examples include contaminated spent solvents, materials contaminated with solvents and radioactive materials, discarded lead shielding and scintillation cocktails.

DOE has estimated that a large fraction (perhaps 60%) of its transuranic waste is in the form of mixed waste.

Types of Radioactive Waste

Low-Level Mixed Waste (LLMW)

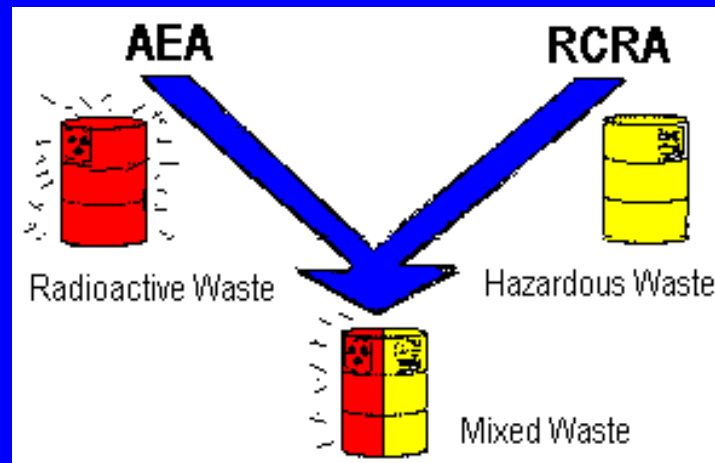
Mixed waste is expensive to dispose of, e.g., several thousand dollars per gallon. Some types might be impossible to dispose of.

Small businesses generating small quantities might be exempt from RCRA requirements if they receive conditionally exempt small quantity generator (CESQG) status (see 40 CFR 261.5)

Information concerning mixed waste is available at <http://www.epa.gov/wastes/hazard/wastetypes/mixed.htm>

Types of Radioactive Waste

Low-Level Mixed Waste (LLMW)



May 16, 2001, the EPA published *40 CFR Part 266 Storage, Treatment, Transportation and Disposal of Mixed Wastes; Final Rule* in the Federal Register (Vol. 66, No. 95, pages 27218 - 27266) that eases the regulatory burden on many generators of mixed waste.

Types of Radioactive Waste

Low-Level Mixed Waste (LLMW)

The Final Rule allows LLMW to be conditionally exempt from RCRA requirements during storage and treatment if it is generated and managed under a single NRC or Agreement State License.

Evaporation and decay in storage are among the available treatment options.

After decay in storage, when the waste is no longer considered radioactive, it becomes subject to RCRA requirements.

Annual inventories and quarterly inspections are required but there is no time limit on storage.

Types of Radioactive Waste

Low-Level Mixed Waste (LLMW)

Certain wastes become nonhazardous following treatments that allow them to meet the land disposal restriction (LDR) standards of 40 CFR 268. Such waste is then no longer subject to RCRA regulation.

The Final Rule also allows LLMW and NARM mixed waste to be exempt from RCRA Subtitle C requirements for transport and disposal.

The waste container must be a carbon steel drum, or its equivalent, or a high integrity container as defined by the NRC. Disposal must meet the acceptance criteria of, and occur at, an NRC or Agreement State licensed low level radioactive waste disposal facility (LLRWDF).

Types of Radioactive Waste

Low-Level Mixed Waste (LLMW)

Disposal of Low Level Mixed Waste must meet the requirements of 10 CFR 61 and the RCRA requirements of 40 CFR 264 and 40 CFR 270. Note that the mixed waste container must thoroughly describe the hazardous component of the waste, not just the radioactive component.

A variety of treatments are available that can eliminate the hazardous component of the mixed waste and allowing it to be disposed of as radioactive waste. In a few cases, the radioactive and hazardous components can be separated.

Some wastes might require vitrification, others (contaminated lead) might require encapsulation, and others such as contaminated oil or solvents might require incineration.

Types of Radioactive Waste

Facilities that Treat/ Dispose of Mixed Waste

1. Perma-Fix Environmental Services, Inc.
Gainesville FL
Primarily employs chemical treatment of solid mixed waste
2. Diversified Scientific Services, Inc. (DSSI)
Kingston, TN
A subsidiary of Perma-Fix. Treats mixed liquid waste by incineration.
3. East Tennessee Materials and Energy Corporation (M&EC)
Oak Ridge, TN
A subsidiary of Perma-Fix. Treats solid and liquid mixed waste via several methods.

Types of Radioactive Waste

Facilities that Treat/ Dispose of Mixed Waste

4. Energy Solutions

Clive, UT

Treats and disposes of specific types of MLLW.

5. NSSI

Houston, TX

Treats a variety of types of mixed waste.

6. Waste Control Specialists

Andrews, TX.

Can treat various mixed waste types including “unimportant quantities” (see 10 CFR 40.13)

Types of Radioactive Waste

Facilities that Treat/ Dispose of Mixed Waste

7. American Ecology

Boise, ID

They treat some types of mixed waste at their sites in Grand View Idaho, and Robstown Texas

International Waste Classification

International Waste Classification

General

There is no standard international approach to the classification of radioactive waste.

The classification systems used in most countries are based, at least in part, on older IAEA recommendations.

Some countries even employ two classification systems: one classifies waste for short-term handling or treatment, and the other is used to classify waste for disposal (long-term handling).

International Waste Classification

Typical Waste Categories

The following classes are fairly typical of those used outside the U.S.

- Exempt Waste (EW)

- Low Level Waste (LLW)

- Intermediate (or medium) Level Waste (ILW)

- High Level Waste

Low and Intermediate Level Wastes (LILW) are often grouped together .

In addition, the low and intermediate level categories are often divided into short lived (LILW-SL) and long lived waste (LILW-LL).

International Waste Classification

Exempt Waste

Concentrations at or below clearance levels, e.g., less than 1 Bq/g and half-life less than 75 days. Dose to public less than 0.01 mSv (1 mrem). No disposal restrictions.

Low Level Waste

Activity above the clearance levels. Contact dose rate < 5 mSv/hr. Examples might include protective equipment/clothing, filters, paper, biological waste, activated concrete. Near surface disposal acceptable.

Intermediate (Medium) Level Waste

Contact dose rate between 5 mSv/hr and 3 Sv/hr. Alpha emitters, if present, at low concentrations. Near surface/geological disposal might be required.

International Waste Classification

Low and intermediate level waste might be grouped together and subdivided into two categories based on half-lives of the radionuclides:

Short Lived Low and Intermediate Level Waste

Half-lives less than 30 years (includes Cs-137 and Sr-90).
Must be isolated from intrusion for 300 years. Near surface disposal possible.

Long Lived Low and Intermediate Level Waste

Half-lives greater than 30 years. Geological disposal required.

International Waste Classification

High Level Waste

Consists of spent fuel and/or wastes from processing spent fuel. Significant concentration of alpha emitters. Contact dose rate greater than 2 Sv/hr. Thermal power greater than 2 kilowatt/m³. Geological disposal required.

International Waste Classification

Current IAEA Recommendations

The latest International Atomic Energy Agency (IAEA) recommendations regarding waste classification are found in IAEA GSG-1 “Classification of Radioactive Waste.” 2009:

- Exempt Waste

- Very Short Lived Waste

- Very Low Level Waste

- Low Level Waste

- Intermediate Level Waste

- High Level Waste

Low Level Waste Classification

Classification of Low Level Waste

General

The NRC (10 CFR 61.55) defines three classes of low level waste suitable for near surface disposal:

Class A

Class B

Class C

Low-level waste that exceeds the class C criteria is known as greater than class C waste (GTCC) and is unsuitable for near surface disposal.

Each waste package (e.g., drum) must be clearly labeled to identify the Class.

Classification of Low Level Waste

Class A Waste

Contains the lowest concentration of short lived and long lived material.

Concentration: Near background to 700 Ci/m^3 (25.9 TBq/m^3)

Examples: Personal protective clothing (PPE), tools, medical wastes, ordinary trash, soil, rubble, depleted uranium.

Stability: Not required but must be segregated from Class B and C if not stable. If stable, segregation not required.

Classification of Low Level Waste

Class B Waste

Intermediate classification. Decay results in acceptable hazard to inadvertent intruder after 100 years.

Concentration: 0.04 to 700 Ci/m³ (25.9 TBq/m³)

Examples: reactor components, sealed sources, filters, resins

Stability: Required. Waste might be inherently stable or the container can provide the stability.

Classification of Low Level Waste

Class C Waste

Contains the highest concentrations suitable for near surface disposal. Deeper burial or barriers required to protect inadvertent intrusion for 500 years.

Concentration: 44 to 7,000 Ci/m³ (1.6 to 259 TBq/m³)

Examples: Ion exchange resins, cooling water filters, activated metals.

Stability: Required. Waste might be inherently stable or the container can provide the stability.

Classification of Low Level Waste

Greater than Class C Waste (GTCC)

Greater than Class C (GTCC) waste is not suitable for near surface disposal.

According to the Low Level Radioactive Waste Policy Amendments Acts of 1985, the U.S. Department of Energy is responsible for providing for the disposal of GTCC wastes. At present, GTCC material must be stored on-site until a suitable disposal option is available. If the licensee is unable to do so, the NRC might request that DOE accept the material.

Examples: activated reactor core shrouds, support plates, filters and resins.

Classification of Low Level Waste

Classifying Low-Level Waste as A, B, C or GTCC

The following two tables, modified from Tables 1 and 2 in 10 CFR 61.55, are intended to illustrate how the NRC regulations classify low-level waste. They are not intended to be used for classification purposes.

If the LLW only contains one nuclide, and it is included in one of the tables, the classification is straightforward.

If none of the nuclides in the LLW are found in the following tables, then the waste is considered Class A.

Classification of Low Level Waste

Table 1 - Long-lived Nuclides

Radionuclide	Concentration in Ci/m ³		
	Class A	Class C	GTCC
C-14	≤0.8	>0.8 to 8	> 8
C-14 in activated metal	≤8	>8 to 80	> 80
Ni-59 in activated metal	≤22	>22 to 220	> 220
Nb-94 in activated metal	≤0.02	>0.02 to 0.2	> 0.2
Tc-99	≤0.3	>0.3 to 3	> 3
I-129	≤0.008	>0.008 to 0.08	> 0.08

* These wastes are Class B unless the concentrations of other nuclides in this table determine the waste to the Class C independent of these nuclides.

Classification of Low Level Waste

Table 1 continued - Long-lived Nuclides

Radionuclide	Concentration in nCi/g		
	Class A	Class C	GTCC
Alpha emitting transuranic with half-life > 5 years	≤ 10	>10 to 100	> 100
Pu-241	≤ 350	>350 to 3,500	> 3,500
Cm-242	$\leq 2,000$	>2,000 to 20,000	> 20,000

Classification of Low Level Waste

Table 2 - Short-lived Nuclides

Radionuclide	Concentration in Ci/m ³			
	Class A	Class B	Class C	GTCC
Total of all nuclides with less than 5 year half-life	≤ 700	*	*	
H-3	≤ 40	*	*	
Co-60	≤ 700	*	*	
Ni-63	≤ 3.5	>3.5 to 70	>70 to 700	> 700
Ni-63 in activated metal	≤ 35	>35 to 700	>700 to 7000	> 7000
Sr-90	≤ 0.04	>0.04 to 150	>150 to 7000	> 7000
Cs-137	≤ 1	>1 to 44	>44 to 4600	> 4600

* These wastes are Class B unless the concentrations of other nuclides in this table determine the waste to be Class C independent of these nuclides.

Classification of Low Level Waste

Classifying Low-Level Waste as A, B or C

When considering more than one nuclide in a given table, we use the sum of fractions approach:

$$\sum_{i=1}^n \frac{C_i}{L_i} < 1$$

C_i is the concentration of nuclide i

L_i is the maximum concentration allowed in the table for a given class (e.g., Class A). Use the highest class that applies to any single nuclide in the waste.

If the sum of fractions is less than 1, the waste falls into that class. If it is greater than 1, the waste belongs to the next higher classification.

Classification of Low Level Waste

Classifying Low-Level Waste as A, B or C

For the case where some nuclides in the waste are found in Table 1 and others are found in Table 2:

If the mix of nuclides in Table 1 is considered Class A, the classification is determined by the nuclides in Table 2.

If the mix of nuclides in Table 1 is considered Class C, the final classification is C or GTCC according to the nuclides in Table 2.

If the mix of nuclides in Table 1 is GTCC, the final classification is GTCC.

Classification of Low Level Waste

Low-level Waste Breakdown by Volume and Activity

	Class A	Class B	Class C
By Volume	97%	2%	1%
By Activity	9%	8%	83%

Slightly more than half the LLW generated in the U.S. comes from nuclear power plants.

The rest comes from medical facilities, research facilities and industry.

Required Waste Characteristics

Required Waste Characteristics

10 CFR 61.56a – General Characteristics

1. “Waste must not be packaged for disposal in cardboard or fiberboard boxes.”
2. “Liquid waste must be solidified or packaged in sufficient absorbent material to absorb twice the volume of the liquid.”
3. “Solid waste containing liquid shall contain as little free standing and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1% of the volume.”
4. “Waste must not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water.”

Required Waste Characteristics

10 CFR 61.56a – General Characteristics

5. “Waste must not contain, or be capable of generating, quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste. This does not apply to radioactive gaseous waste packaged in accordance with paragraph (a) (7) of this section.”
6. “Waste must not be pyrophoric. Pyrophoric materials contained in waste shall be treated, prepared, and packaged to be nonflammable.”
7. “Waste in a gaseous form must be packaged at a pressure that does not exceed 1.5 atmosphere at 20 degrees C. Total activity must not exceed 100 curies per container.”

Required Waste Characteristics

10 CFR 61.56a – General Characteristics

8. “Waste containing hazardous biological, pathogenic, or infectious material must be treated to reduce the maximum extent practicable the potential hazard from the nonradiological materials.”

Required Waste Characteristics

10 CFR 61.56b - Stability

“Stability is intended to insure that the waste does not structurally degrade and affect overall stability of the site through slumping, collapse, or other failure of the disposal unit and thereby lead to water infiltration.”

Stability is also a factor in limiting exposure to an inadvertent intruder. For additional information about this topic see the NRC Information Notice IN 89-27 *Limitations on the Use of Waste Forms and High Integrity Containers for the Disposal of Low-Level Radioactive Waste*.

Required Waste Characteristics

10 CFR 61.56b - Stability

1. “Waste must have structural stability. A structurally stable waste form will generally maintain its physical dimensions and its form, under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture, microbial activity, and internal factors such as radiation effects and chemical changes. Structural stability can be provided by the waste form itself, processing the waste to a stable form, or placing the waste in a disposal container or structure that provides stability after disposal.”

Required Waste Characteristics

10 CFR 61.56b - Stability

2. “Notwithstanding the provisions in 61.56(a)(2) and (3), liquid wastes, or wastes containing liquid, must be converted into a form that contains as little free standing and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1% of the volume of the waste when the waste is in a disposal container designed to ensure stability, or 0.5% of the volume of the waste processed to a stable form.”
3. “Void spaces within the waste and between the waste, and its package must be reduced to the extent practicable.”

Waste Containers

Waste Containers

Strong Tight Container

Could be a metal box or a wooden box reinforced with metal straps. Only needs to be capable of surviving routine handling and transportation. Suitable for limited quantity waste, i.e., activity does not exceed one thousandth of the A_1 or A_2 values (whichever applies). Not all strong tight containers are acceptable for waste disposal.

Type A Container

Could be metal box or drum. Must be capable of surviving minor accidents as well as routine handling and transportation. Suitable for waste with activities between one thousandth of the A_1 or A_2 values (whichever applies) and the A_1 or A_2 value.

Waste Containers

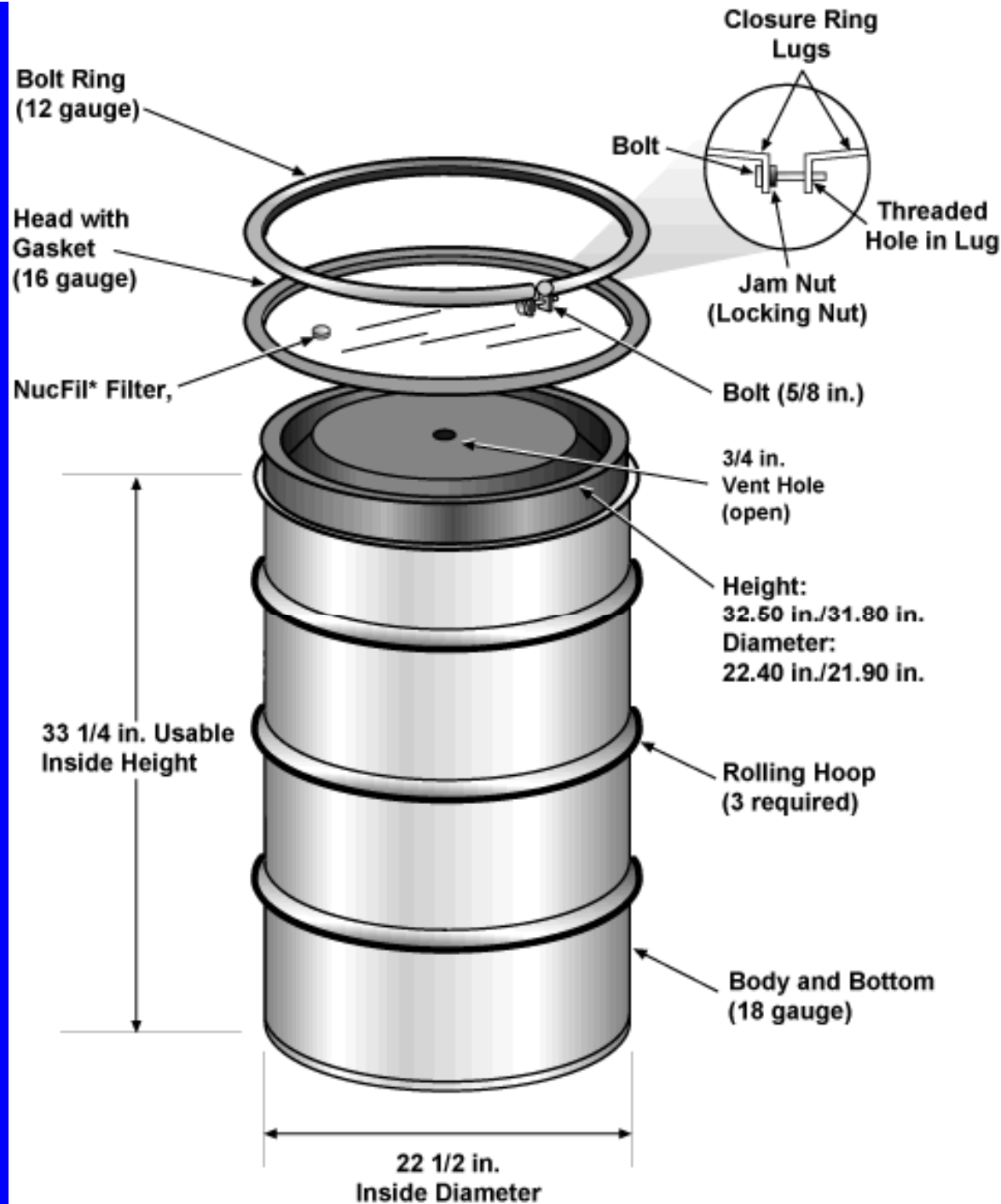
Type B Container

Could be metal drum or large shielded metal transport container. Must be capable of surviving severe accidents as well as routine handling and transportation. Suitable for waste with activities exceeding the A_1 or A_2 values (whichever applies).

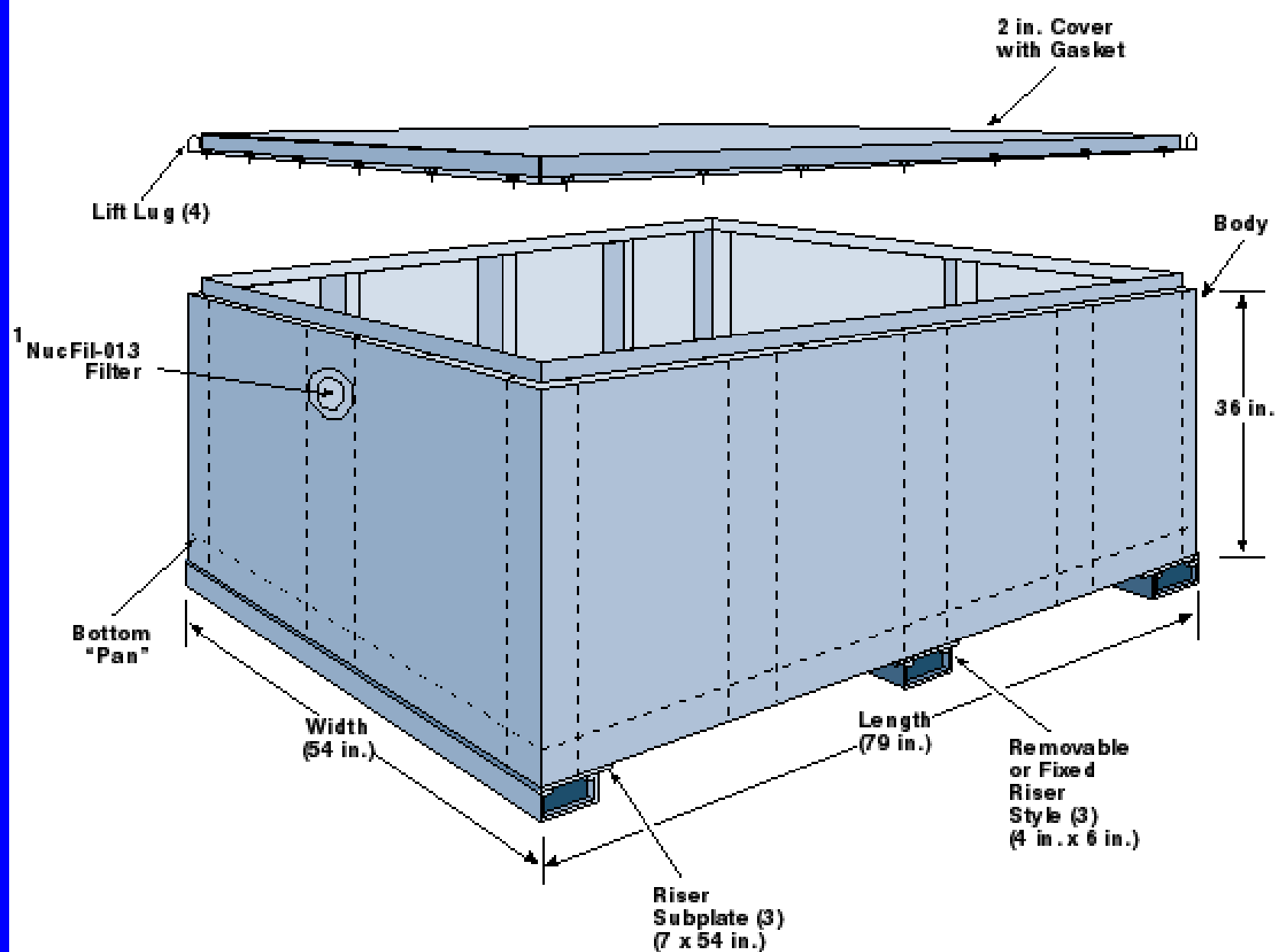
Low Specific Activity (LSA) Packaging

LSA waste might require either a strong tight container or a type B container depending on the total activity.

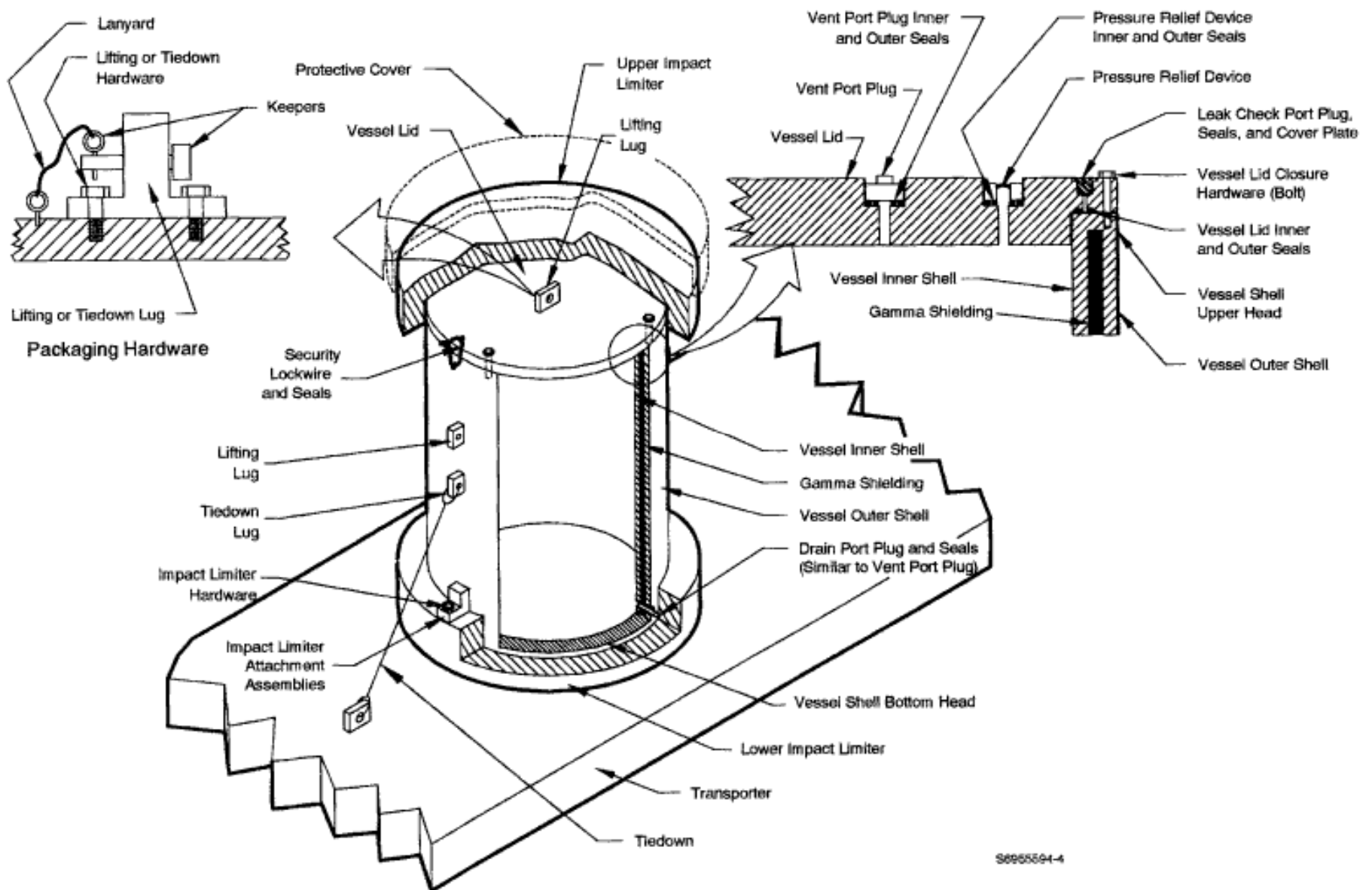
Type A Container



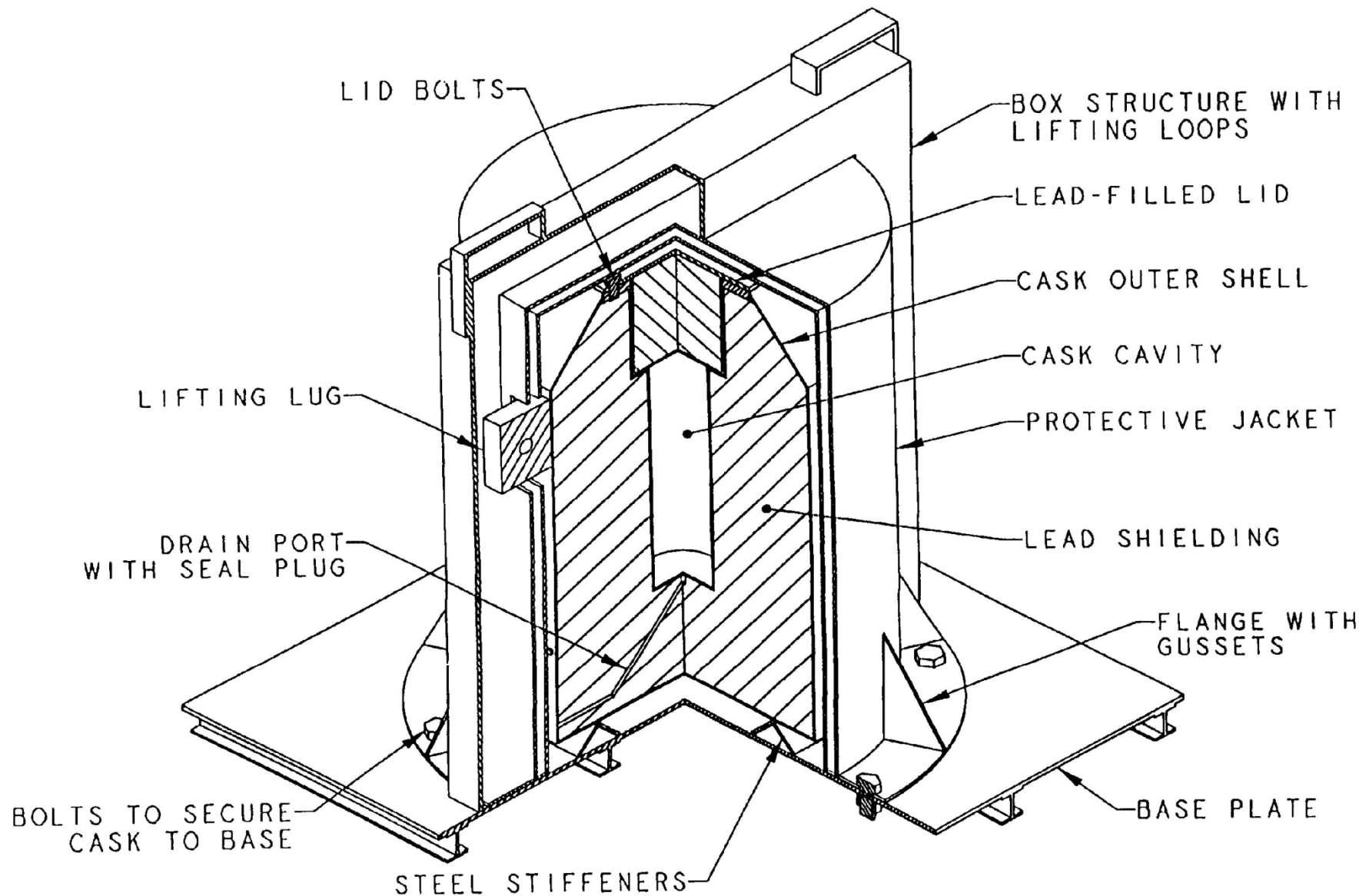
Type A Container



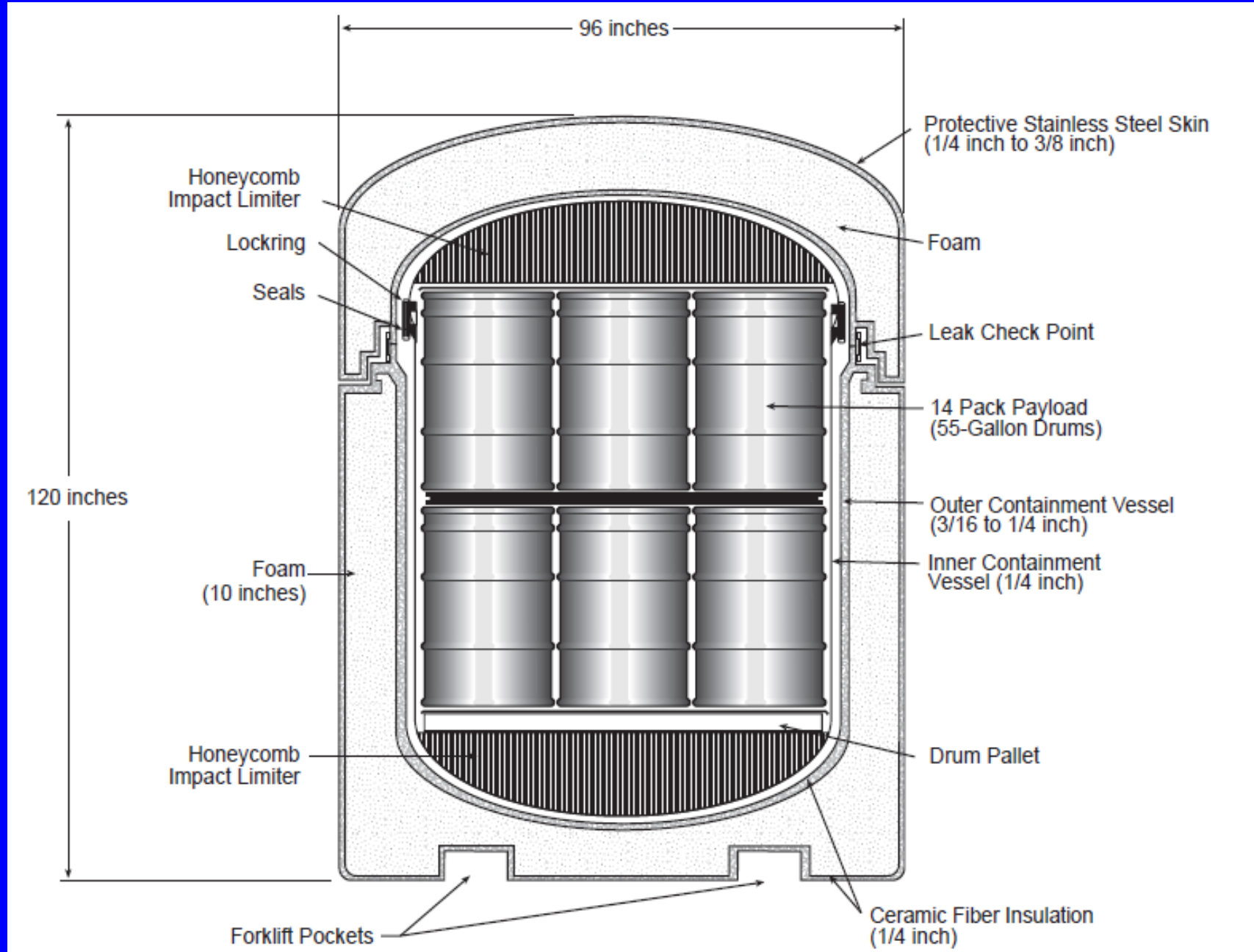
Type B – Normal Form Container



Type B – Special Form Container



TRUPACT-II Container for Transuranic Waste



Waste Containers

Example Instructions for Packaging Liquid Waste

Method One

1. Place a 4 mil. poly liner into a type A drum.
2. Place a layer of approved absorbent into the poly-lined drum.
3. Slowly add liquid to the absorbent being careful to insure the liquid is thoroughly absorbed. The ratio between absorbent to liquid is 2:1. 4. Continue adding layers of absorbent and liquid until the drum is full.
5. Seal the poly bag.
6. Install the gasket and lid.

Waste Containers

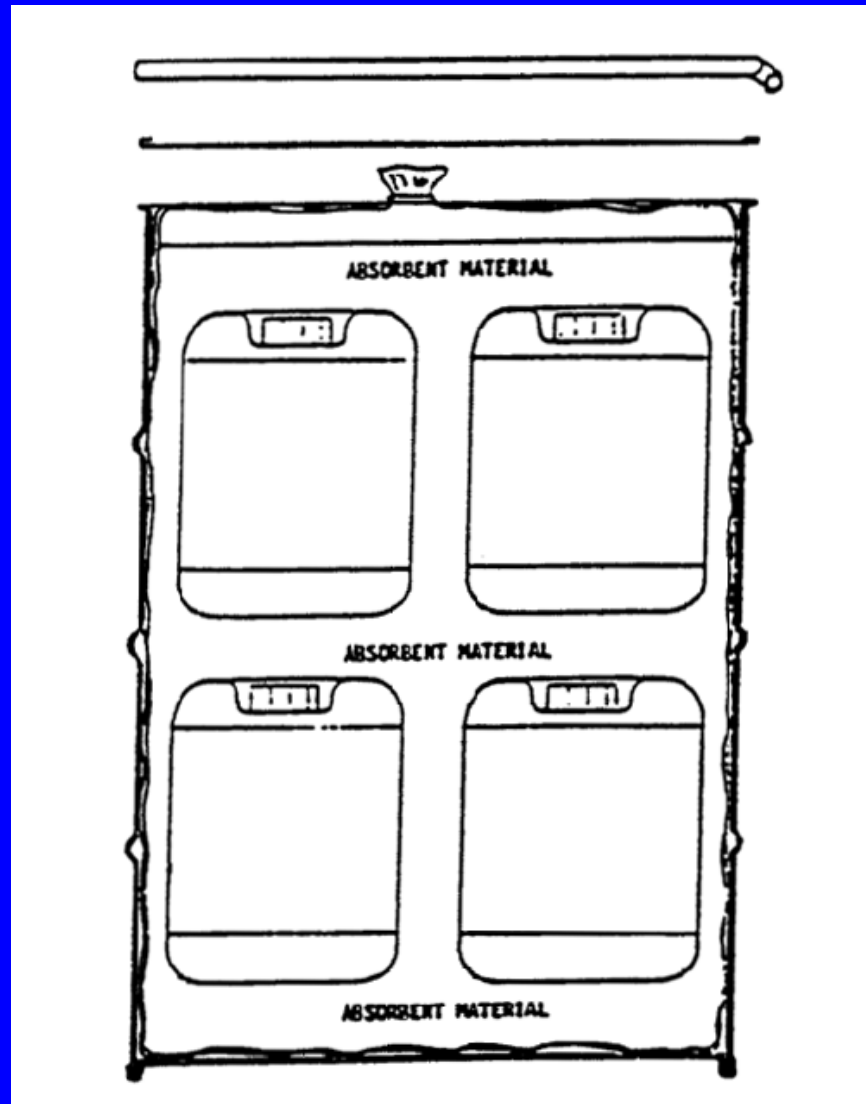
Example Instructions for Packaging Liquid Waste

Method Two

1. Place an approved absorbent into a poly bottle or carboy.
2. Add liquid to the absorbent filled bottle. Don't exceed 2:1 ratio (absorbent to liquid)
3. Install the lids on the bottles.
4. Place the filled poly bottles into a DOT specification 7-A drum with an approved absorbent placed around the bottles to fill all void spaces.
5. Install the drum gasket and lid.

Waste Containers

Example Instructions for Packaging Liquid Waste



Waste Disposal Sites

Waste Disposal Sites

High-Level Waste Disposal

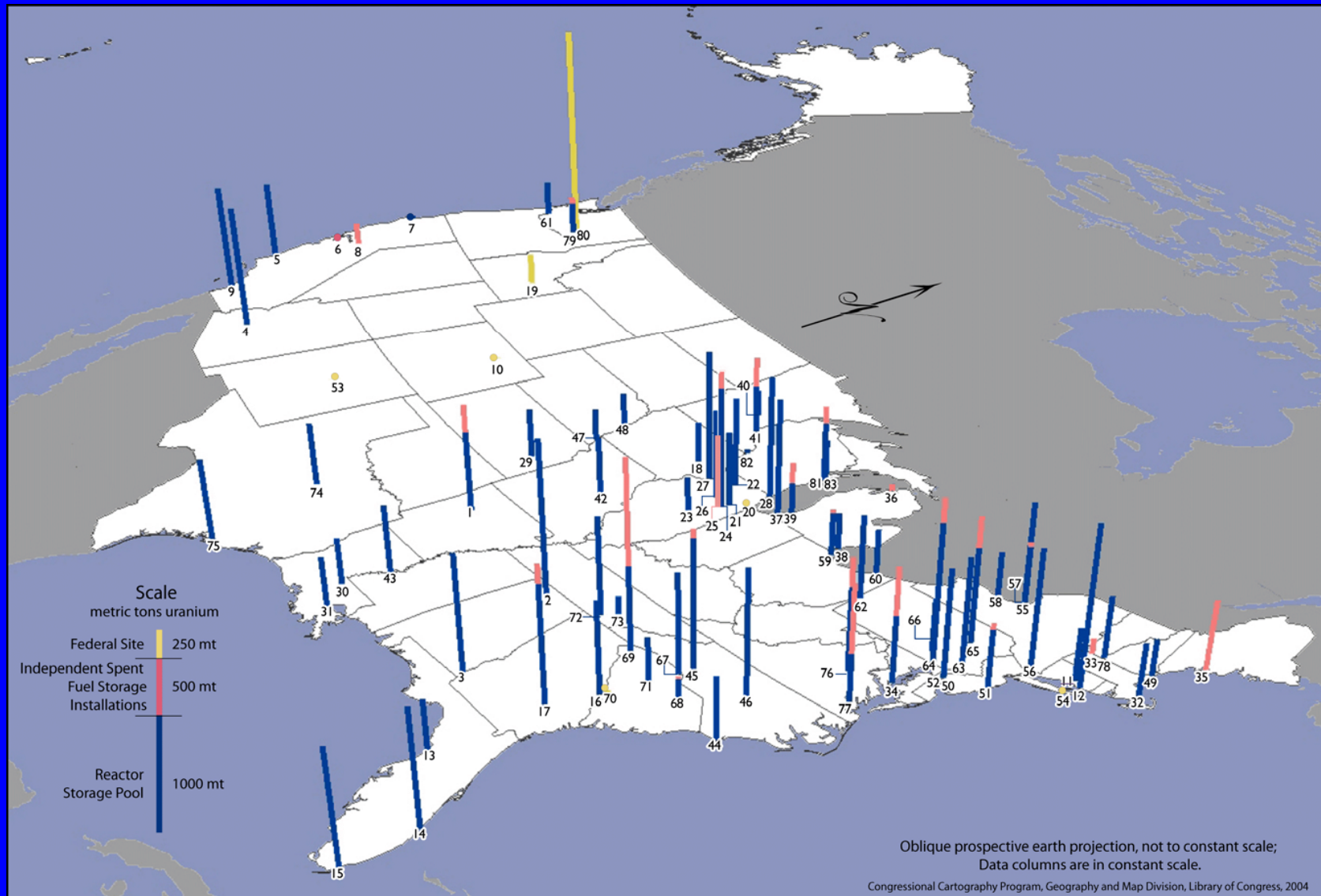
At present, no disposal site for HLW exists, in the U.S., or elsewhere.

The 1982 Nuclear Waste Policy Act called for the Department of Energy to begin accepting spent fuel from nuclear power plants in 1998. DOE has submitted a license application to the NRC for repository construction at Yucca Mountain, but the Obama administration has effectively halted the process.

Most of the U.S. high-level waste (including over 10,000 tons of commercial spent fuel) is in storage at the site of origin in pools or dry casks. Some is stored at West Valley, NY; the ID National Engineering Laboratory at Idaho Falls, ID; and the Midwest Fuel Recovery Plant at Morris, IL.

Waste Disposal Sites

High-Level Waste Disposal



Waste Disposal Sites

High-Level Waste Disposal



Dry cask storage of spent fuel

Waste Disposal Sites

High-Level Waste Disposal

Yucca Mountain, approximately 120 miles northwest of Las Vegas on the border of the Nevada Test Site, is the only site in the United States approved by Congress for the disposal of high level waste. Its advantages as an HLW repository include:

- The site is remote.
- The property is controlled by the Federal Government.
- The Nevada Test Site is already contaminated.
- The soil is very dry.
- The water table is very deep.
- The minerals in the soil are strongly adsorptive.

Waste Disposal Sites

High-Level Waste Disposal



Yucca Mountain Tunnel Entrance



Yucca Mountain

Waste Disposal Sites

High-Level Waste - Problematic Radionuclides

The long-lived fission products and transuranics of most concern in HLW are:

Tc-99	(2.11×10^5 years) beta, no gamma
I-129	(1.57×10^7 years) beta, low energy gammas
Np-237	(2.14×10^6 years) alpha, low intensity low energy gammas. gammas of concern primarily from the decay product Pa-233 (27 d)
Pu-239	(2.41×10^4 years) alpha, very low intensity gammas

Waste Disposal Sites

High-Level Waste - Problematic Radionuclides

Other long-lived fission products of concern:

Sn-126	$(2.3 \times 10^5 \text{ years})$
Se-79	$(2.95 \times 10^5 \text{ years})$
Zr-93	$(1.53 \times 10^6 \text{ years})$
Cs-135	$(2.3 \times 10^6 \text{ years})$
Pd-107	$(6.5 \times 10^6 \text{ years})$

Waste Disposal Sites

High-Level Waste - Problematic Radionuclides

Medium-lived fission products of concern:

Eu-155 (4.75 years)

Kr-85 (10.76 years)

Cd-113m (14.1 years)

Sr-90 (28.79 years)

Cs-137 (30.08 years)

Sn-121m (55 years)

Sm-151 (90 years)

Waste Disposal Sites

High-Level Waste Disposal in France

In France, the spent fuel generated at reactors is reprocessed (after approximately three years of storage). This involves chemically extracting the uranium and plutonium for reuse as fuel.

The remaining waste is separated into Intermediate-Level Waste (ILW) and High-Level Waste (HLW).

The ILW is put in drums and solidified with cement into concrete.

The HLW is vitrified and poured into stainless steel casks which are put in dry storage.

Waste Disposal Sites

Transuranic Waste Disposal

The WIPP (Waste Isolation Pilot Plant) facility, operated by the Department of Energy (DOE), is 26 miles east of Carlsbad, NM. It serves as a repository for transuranic waste generated by the defense industry.

Transuranic wastes not tied to the Department of Defense are being stored in a retrievable form at the sites where they are produced.

Since disposal costs at WIPP are very high, waste that might have to be classified as TRU waste is analyzed very carefully to ensure that it cannot be disposed of as simple LLW.

Waste Disposal Sites

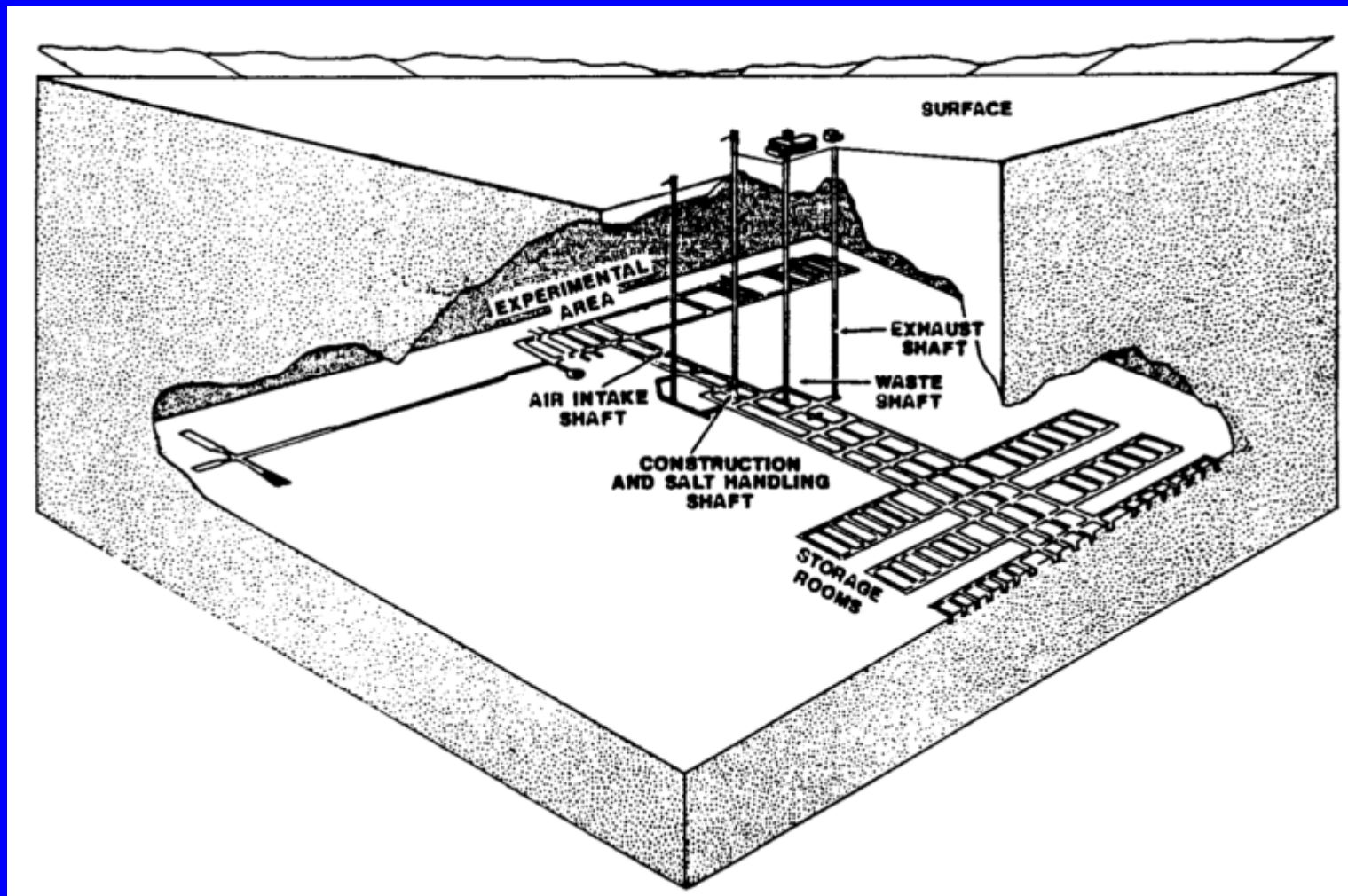
Transuranic Waste Disposal

At WIPP, the wastes are buried, in a recoverable form, in salt formations at a depth of approximately 2000 feet. The advantages of the site include the following:

- The geology is stable with little earthquake activity.
- The salt formations almost by definition indicate the absence of groundwater.
- Salt is a plastic material that will seal any fissures or voids that may occur.
- The site is located in a remote area.

Waste Disposal Sites

Transuranic Waste Disposal



WIPP Site

Waste Disposal Sites

Transuranic Waste Disposal



The two types of TRU waste:

contact handled

remote handled

Although WIPP has been receiving contact handled TRU waste for some time, it has only recently been accepting remote handled TRU.

Waste Disposal Sites

Low-level Waste Disposal

The Department of Energy operates its own low level waste sites, although it also ships LLW to commercial sites.

Four LLW waste disposal sites in the U.S. have closed: Beatty, NV; Maxey Flats, KY; West Valley, NY; Sheffield, IL.

There are three operating commercial low level waste disposal sites:

Barnwell, SC

Richland, WA

Clive, UT

A fourth, in Andrews county, Texas, is expected to begin accepting waste in the spring of 2011.

Waste Disposal Sites

Low-level Waste Disposal

The site in Barnwell, SC is operated by Chem-Nuclear (a subsidiary of EnergySolutions) .

Barnwell continues to accept all three classes of LLW, but from a very limited number of states: Connecticut, New Jersey and South Carolina.

The Richland, WA disposal facility is operated by American Ecology.

Richland, like Barnwell, accepts Class A, B and C waste. It only accepts waste from states in the Northwest (Washington, Oregon, Idaho, Montana, Utah, Wyoming) and Rocky Mountain (Colorado, Nevada, New Mexico) Compacts.

Waste Disposal Sites

Low-level Waste Disposal

Clive, UT is operated by *EnergySolutions* .

The low level waste disposal site was once known as Envirocare .

It only accepts Class A LLW. However, it will accept some types of mixed waste for burial.

The bulk of the Class A waste that it accepts consists of contaminated soil and mill tailings.

If waste can be sent to Clive, it will cost less than sending the waste to either Richland or Barnwell.

Waste Disposal Sites

Low-level Waste Disposal

The Andrews County, TX is operated by Waste Control Specialists.

It has been licensed to accept all types of low level radioactive waste from Texas, Vermont and the Federal Government. A proposal is being evaluated that would permit waste to be accepted from any state.

Although the license has been approved, the Andrews County site is not yet accepting waste for disposal.

The facility is expected to begin disposing of waste in late 2011.

Waste Disposal Sites

Low-level Waste Disposal



Above: engineered cap/cover over filled "trench" Barnwell

Barnwell puts waste in below ground concrete vaults. A drainage system directs water away from the waste and into a sump.

Waste Disposal Sites

Low-level Waste Disposal



Packaging and Transportation Issues

Packaging and Transportation Issues

Waste Acceptance Criteria (WAC)

- detail a given waste site's requirements for license compliance (e.g., characterization, packaging, required documentation).
- identify the limitations on isotope acceptability and waste form.
- can be more restrictive than regulatory requirements.
- are usually available at the waste facility's web site.
- waste shipments must comply with the acceptance criteria.

Packaging and Transportation Issues

DOT Requirements

Shipments of radioactive waste to a site must comply with the DOT regulations pertaining to the shipment of radioactive material.

These regulations address a variety of issues including the labeling and marking of the packages, vehicle placarding, shipping manifests, exposure rate limits and contamination limits.

Packaging and Transportation Issues

DOT Exposure Rate Limits for Packages

Non-Exclusive Use Carrier

Container surface:	200 mR/hr
One meter from container surface (TI):	10 mR/hr

Exclusive Use Carrier - open transport vehicle

Container surface:	200 mR/hr
One meter from container surface (TI):	10 mR/hr

Exclusive Use Carrier - closed transport vehicle

Container surface:	1000 mR/hr
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Packaging and Transportation Issues

DOT Exposure Rate Limits for Exclusive Use Vehicles

Surface of the vehicle:	200 mR/hr
Two meters from the vehicle:	10 mR/hr
Occupied portions of vehicle cab:	2 mR/hr

DOT Contamination Limits

Total

Beta-gamma & low toxicity alpha:	22,000 dpm/100cm ²
High toxicity alpha:	2,200 dpm/100cm ²

Removable

Beta-gamma & low toxicity alpha:	2,200 dpm/100cm ²
High toxicity alpha:	220 dpm/100cm ²

Packaging and Transportation Issues

Inspections of Waste Shipments

Waste shipments are inspected extremely carefully when they reach the waste disposal site. If the shipment fails the inspection, it can be sent back to its origin at the expense of the facility that shipped the waste.

Waste shipments can be inspected before they leave the facility that generated the waste.

The state might inspect the waste shipments while they are on route to the waste disposal site.

Packaging and Transportation Issues

Common Reasons Why Shipments Fail Inspections

1. Placards missing on truck and trailer.
2. High radiation levels, e.g., underside of trailer.
3. Excessive contamination on trailer.
4. Damaged/leaking packages.
5. Packages not braced.
6. Package bolt rings/latches not tight.
7. Improper container.
8. Contaminated packages.
9. Radionuclides not identified or activity not specified.
10. State certificate (e.g. Washington/Nevada) missing.
11. Shipping papers lack exclusive use directions when required.

References

Hotte and Sokolek. Operational Radiation Safety Aug. PS21-S23, 2001.

NRC. "Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety." NUREG/CR-6407. 1996.

NRC. "Scope of Exemption in 10 CFR 20.303 (d) for Disposal of Patient Excreta in Sanitary Sewers" HPPOS-035.

NRC. "Categorizing and Transporting Low Specific Activity Materials and Surface Contaminated Objects." NUREG-1608. 1998.

NRC. "Standard Review Plan for Transportation Packages for Radioactive Material." NUREG-1609. 1999.

Waste Brokers

Waste Brokers

General

Waste disposal brokers can assist in the processing and/or disposal of radioactive waste. A list of waste brokers is regularly updated on the CRCPD website.

Advantages:

1. Brokers can reduce the paperwork associated with waste disposal.
2. They can supply the waste containers as well as packing materials, e.g., absorbents, pipes, bags.
3. The broker can make disposal more cost effective by using volume reduction methods normally unavailable to a typical licensee..

Example Forms and Labels